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ABSTRACT

Reviewing current conditions and projecting future directions, this paper explores trends in high school mathematics and discusses their implications for two-year college education. The first section examines the secondary school mathematics program, indicating that until now this two-track curriculum has focused on precalculus mathematics for college-bound students and a year of general math, often followed by consumer or vocational mathematics for non-college-bound students. This section reviews the flexible curriculum suggested by the National Council of Teachers of Mathematics for all students and notes its failure to materialize. The next section examines achievement trends among high school students, citing the relatively stable achievement of 17-year olds in the 1973, 1978, and 1982 national assessments of mathematics. After a brief discussion of the shortage of qualified mathematics teachers in certain areas of the United States, the paper reviews federal, state, and local initiatives for improving math education. The next sections project future curriculum trends toward emphases on discrete math, statistics and probability, and computer science, and look at the probable impact of computers and calculators on math education. The next section looks at the changing nature and influence of standardized, locally developed criterion-referenced, and College Board tests. Finally, the implications of these trends for two-year college mathematics are discussed, and the argument is made that two-year colleges should take a proactive role and work directly with feeder schools. (HB)

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AND TWO-YEAR COLLEGES
by Ross Taylor

SUMMARY

Today school mathematics is receiving greater attention than at any time since the flurry of activities following the launching of Sputnik in 1957. A Nation At Risk and many other national reports have called for an increased emphasis on mathematics. As we move into the information age, a person's mathematical knowledge will be a significant factor in determining whether the person will be a "have" or a "have not" in the new society.

Until now the secondary school mathematics program has tended to concentrate on two areas: preparation for four-year colleges, and basic skills instruction. The flexible curriculum to meet the diverse needs of all students called for in the National Council of Teachers of Mathematics Agenda for Action has yet to materialize.

Achievement of seventeen-year-olds has been stable in the 1973, 1978 and 1982 national assessments of mathematics. Students tend to be relatively strong in whole number computation, but they are weak in higher level mathematical skills. In many areas of the country there is a shortage of qualified mathematics teachers.

In the future we can anticipate greater curriculum emphasis in discrete mathematics, statistics and probability, and computer science. We can expect to see gradual infusion of recommended changes into textbooks and hence into instruction. The impact of computers and calculators on instruction will likely be uneven from school to school. Standardized tests will tend to follow the trends, rather than lead them. However, locally developed criterion referenced tests and College Board tests could be trend setters. In the absence of federal initiatives, curriculum changes will tend to be more local in nature than they were in the wake of Sputnik.

Two-year colleges should take a proactive role and work directly with their feeder high schools to help them give their students better preparation for post-secondary education.

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MATHEMATICS PROGRAMS IN HIGH SCHOOLS
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High School Mathematics Programs

Recommendation 6 of An Agenda for Action: Recommendations for School Mathematics of the 1980s states that:

> More mathematics study be required for all students and a flexible mathematics curriculum with a greater range of options be designed to accommodate the diverse needs of the student population.

The Agenda goes on to recommend that at least three years of mathematics should be required in grades 9 through 12. The report of the National Commission on Excellence in Education: A Nation at Risk also recommends that at least three years of mathematics and a half year of computer science be required in grades 9 through 12. If these recommendations were implemented, the result would be a significant change in the mathematics requirements in high schools throughout the country. Today, many of the nation's schools require only one year of mathematics in grades 9 through 12; a lesser number require two years of mathematics and still fewer require three years.

Up until this time, the high school mathematics curriculum has been essentially a two-track program. The precollege program has focused on precalculus mathematics including programs in elementary algebra, geometry, advanced algebra and precalculus. Typically, trigonometry has been included in combination with advanced algebra, precalculus, or both. The program for the noncollege bound has consisted of a year of general mathematics at ninth grade followed up in some cases with a year or more of consumer or vocational oriented basic mathematics. The Position Paper on Basic Mathematical Skills of the National Council of Supervsors of Mathematics (NCSM) states that all students need a mathematics program that includes more than computational

skill. In particular, the NCSM Position Paper established that all students should aquire skill in the following ten vital areas:

1. Problem Solving
2. Applying Mathematics to Everyday Situations
3. Alertness to Reasonableness of Results
4. Estimation and Approximation
5. Appropriate Computational Skills
6. Geometry
7. Measurement
8. Reading, Interpreting, and Constructing Tables, Charts and Graphs
9. Using Mathematics to Predict
10. Computer Literacy

The NCSM Position Paper also points out that employment and educational opportunities will continue to increase as mathematical skills continue to grow beyond the ten basic skill areas.

As we move from an industrial society to an information society, one's opportunities will be determined to an increasing extent by one's ability to function with technology. In addition to communication skills, one's mathematical background will be a significant determiner of whether one will be a "have" or a "have not" in future society.

The transition from a two track (or more accurately a one plus a fraction track) mathematics curriculum to a flexible mathematics curriculum that meets the diverse needs of all students is neither swift nor easy. Mathematics teachers are products of college preparatory precollege mathematics. Most of them received their undergraduate education in four-year colleges and universities. Morever, most school administrators and counselors also received their undergraduate training in four-year institutions. As a result, their education and experience does not orient them to the two-year colleges.

Moreover, the attention of the schools tends to focus on the ends of the academic spectrum. From the middle seventies on, the minimum competency programs spurred by the back to the basics forces have tended to focus on students at the lower end. In the eighties, the code word has been excellence with a resulting focus on gifted and talented students. In the process, the large group of students in the academic middle have not received the attention they deserve. To a large extent, this is the group of students that is served by community colleges. In the absence of more appropriate mathematics programs and better counseling for those students, the two-year colleges have had to dissipate a large proportion of their resources on remedial programs that address mathematical competencies that students should have acquired in high school, in junior high school, or even in elementary school.

Achievement Trends

As two-year colleges plan their mathematics programs for the rest of the eighties and on into the nineties, the planners need to be aware of current trends in elementary and secondary schools that will affect them in the future. Achievement of seventeen-year-olds has remained relatively constant in the three national mathematical assessments in 1973, 1978 and 1982. Achievement of thirteen-year-olds increased from 1978 to 1982. Achievement of Blacks and Hispanics is far below that of White students at all three age levels. However, the gaps have been decreasing for nine-year-olds since 1973 and for thirteen-year-olds since 1978. The infusion of federal Title I/Chapter I funds into compensatory programs in urban elementary schools is one of several possible explanations for these trends. In the future, the increases in achievement for all students and the decreases in the achievement gaps between minority and majority students may show up at the seventeen-year-old level. Whether or not these trends will continue as the

students move through the secondary schools remains to be seen. There is no federal effort at the senior high school comparable to the Chapter I program which spends over three billion dollars annually in compensatory programs in reading and mathematics concentrated at the elementary level. In any case, students tend to achieve well on lower level skills such as whole number computation and they tend to have difficulty with higher level skills such as problem solving. No immediate turnaround in this pattern appears to be likely. Mathematics educators are particularly concerned about the low level of achievement in higher level thinking skills because these are the skills that students will need in order to be effective contributors in future society.

The long gradual downward slide in Scholastic Aptitude Test (SAT) scores appears to have bottomed out.

Public support for mathematics instruction is high. For example, in the 1983 Gallup Poll on Education mathematics was rated as the most important of all of the subjects both for college-bound and noncollege-bound students. The school effectiveness movement has taken hold with school boards and top school administrators. The result has been an emphasis on practices that raise achievement, particularly in the areas of reading in mathematics. The flames of public interest fanned by national reports such as A Nation at Risk have produced pressures at that local and state levels to increase high school mathematics requirements and upgrade the mathematics curriculum. In 1983 the National Commission on Excellence in Education reported that the nation's schools were being overwhelmed in a "rising tide of mediocrity." A year later, the U.S. Department of Education issued a report entitled The Nation Responds that claimed that the report of the National Commission on Excellence had produced "a tidal wave of school reform." The Department of Education 1984 report cited 275 state level task forces that had worked during 1983-84

to improve education. A total of 48 states are considering stiffer high school graduation requirements and 35 already have approved changes. In the present national environment, the stiffer requirements will probably affect mathematics as much or more than any other discipline.

The Mathematics Teacher Shortage

A shortage of qualified mathematics teachers continues to be a problem in many areas of the country. However, the shortage appears to be spotty. For example, high schools in affluent areas are generally well staffed. However, there are shortages in many rural and urban school systems, particularly in the junior high and middle schools. Reports from schools of education indicate that undergraduate students have heard about the shortage of mathematics teachers and, as a result, many more are coming through the pipeline. For example, since 1980 the number of undergraduates in mathematics education at the University of Minnesota has increased from under 40 to over 100. In addition, a number of teachers from other fields have entered graduate retread programs to prepare them to teach mathematics. Unfortunately, some areas of the country have addressed the issue by relaxing certification standards so that warm bodies could be found to staff the classrooms.

Sputnik and A Nation at Risk

Perhaps A Nation at Risk, the report of the Commission on Excellence in Education, will identify 1983 as a major reference point in educational reform, just as the launching of Sputnik identified 1957 as a benchmark year. In each case, international competition was a major factor that gave impetus to the reform. In 1957 the Russians were the competitors and the area of competition was aerospace and military technology. In 1984 the major

competitors are the Japanese and the area of competition is economic with concentration on high technology industries. At this time we are seeing an emphasis on improving education that appears to be at least as intense as the efforts that followed the launching of Sputnik in 1957. Sputnik was accompanied by massive national curriculum development efforts in science and mathematics, funded primarily by the National Science Foundation (NSF). In addition, NSF funded numerous teacher education programs for upgrading the mathematics and science knowledge of teachers. The NSF summer and academic year programs for teachers tended to be national in scope with teachers from all parts of the country attending institutes at various colleges and universities.

The patterns for improvement today are much different than they were in the wake of Sputnik. Initiatives from the federal government have been slow in coming, so responsibility has fallen more at the state and local levels. At this there are no massive federally funded curriculum development projects such as the School Mathematics Study Group (SMSG) or the University of Illinois Committee on School Mathematics (UICSM) of the late fifties and the sixties. For similar activities to take place today, a dramatic shift in emphasis in Washington or major private funding would be required. Similarly, today staff development efforts are much more local in nature than they were following Sputnik. In the absence of federal initiatives, states are allocating resources for staff development. For example this year Minnesota has allocated over half a million dollars for teacher education programs in the areas of science, mathematics and social science; in 1984 Florida allocated 9.4 million dollars for staff development and summer programs in mathematics and science.

The one area where today's efforts are national in scope is that of holding conferences. One leader in mathematics education indicated to me

recently that if the problems in mathematics education could be solved by conferences, they certainly would all be solvec by now. Of course, each conference produces a report and, in addition, there are individually commissioned reports not related to specific conferences. This situation caused a mathematics educator to remark that right now we are in less danger of being overwhelmed by a rising tide of mediocrity than we are of being overwhelmed in a rising tide of reports on education.

Future Curriculum Trends

Of the many recent reports on education, two that could have significant impact on mathematics education are the Conference Board of the Mathematical Sciences report to the National Science Board (NSB) Commission on Precollege Education in Mathematics, Science and Technology and the report of project EQuality of the College Board. Both of these reports were developed prior to the publication of A Nation at Risk. The two reports are general in nature, leaving the details to be filled in at a later time, yet they serve as an indication of future trends.

The report of the Conference Board is entitled "The Mathematical Sciences Curriculum K-12: What is still fundamental and What is Not." Here is a summary of the recommendations with regard to the secondary school mathematics curriculum.

> We recommend:
>
> That the traditional component of the secondary school curriculum be streamlined to make room for important new topics. The content, emphasis and approaches of courses in algebra, geometry, precalculus, and trigonometry need to be reexamined in light of new computer technologies.
>
> That discrete mathematics, statistics and probability, and computer science now be regarded as "fundamental" and that appropriate topics and techniques from these subjects be introduced into the curriculum. Computer programming should be included at least for college-bound students.

The report of project EQuality entitled "Academic Preparation for College: What Students Need to Know and Be Able to Do." states:

> Students going to college need mathematical skills beyond the elementary ones. They need a knowledge of computing to deal with the new age of computers and information systems. They need a knowledge of algebra, geometry, and functions to major in a wide range of fields from archaeology to zoology. They need a knowledge of statistics for such fields as business, psychology, and economics.
>
> More extensive knowledge and skills, including preparation for calculus, will be needed by college entrants who expect to take advanced mathematics courses or to major in such fields as engineering, economics, premedicine, computer science, or the natural sciences.

Today mathematics instruction in the schools tends to be influenced primarily by the textbooks. Publishers are quick to pick up on new trends while at the same time being cautious not to publish radically different texts before the consumers are ready to purchase them. If present trends continue, in coming years we will see a gradual infusion of the recommended changes into the texts and consequently into instruction.

The Impact of Computer and Calculators

The change needed as a result of new computer and calculator technology causes a particular dilemma in mathematics education today. The technology is changing so rapidly that it is difficult to know what students will need in the future. For example, how much programming will students need, and in what languges? Will changes in hardware and software make programming as we know it today largely obsolete within a few years? Inexpensive hand-held calculators have been available since the middle seventies, yet the impact of calculators on the mathematics curriculum has been relatively minimal.

Use of computer timesharing in mathematics instruction appeared to flatten out at a relatively low level during the early seventies. The microcomputer boom in the early eighties has caused a spurt in the use of computers in all aspects of education. Yet today mathematics teachers use computers primarily

for drill and practice in low level skills and for teaching courses in programming. The recommendation of the National Council of Teachers of Mathematics 1980 Agenda for Action that "mathematics programs take full advantage of the power of computers and calculators at all grade levels" is a long way from universal implementation. Availability of computers is spotty with access varying from relatively good in some schools to nonexistent in others. In addition to a shortage of hardware, in many schools there is a shortage of teachers with knowledge of how to effectively use computers in instruction. In the past few years we have seen a proliferation of computer software, yet much of it is of low quality and a high proportion is designed for drill and practice of low level skills. We are still looking to the future for widespread use of computers in a variety of creative ways in mathematics instruction. The potential of the computer for demonstration, problem solving, inquiry, simulation, instructional management, generation of materials and other applications is yet to be realized.

The initiation of the advanced placement exam in computer science in 1984 is another step in the infusion of computer technology into the curriculum. The number of students taking the computer science advanced placement exam is relatively small. We can expect the number to grow in future years, but there are factors that will restrict the growth: the difficulty of the course, the already crowded curriculum, and the lack of qualified teachers. There is a fear that teachers who become well qualified to teach the course will be hired away by industry.

There is a danger that computers, which have so much potential for education, can magnify the inequities that already exist in our society today. Just as inequities in mathematics participation by sex are being reduced, we are witnessing great inequities by sex in computer classes and supplementary uses of computers. Schools in affluent areas tend to have more

computers and more teachers with knowledge of computers. Students from more affluent homes are the ones who have computers at home. We can expect to see great diversity in the ability of our student population to use computers; today we have some students who are computer whizzes by the time they leave elementary school and others who still have no computer experience when they leave high school.

The Influence of Tests

Tests can be powerful tools for improving instruction or for perpetuating the status quo. Traditionally standardized tests tend to follow the trends rather than lead them. While there are new texts on the market every year, the situation is different with standardized norm-referenced tests. There are only a handful of test publishers and the tests are revised infrequently, with a revision cycle that can range from six to ten years. Occasionally we see innovative textbooks that address the needs of a small percent of the national market. However, such is not the case with standardized tests.

In contrast to the standardized norm-referenced tests, the advanced placement tests and scholastic aptitude tests of the Educational Testing Service (ETS) can lead trends. The advanced placement computer science test is an example of such leadership. New tests are prepared by ETS each year and the College Board informs the schools well in advance of any impending significant changes. As the specifics of the project EQuality recommendations are more precisely defined, the College Board tests published by ETS will be instruments for change.

In the near future, the tests that will have the greatest impact will be the ones that are developed at the state and local levels. An example is the screening test developed by Ohio State University which was administered to 61,050 high school juniors throughout Ohio in 1984. After taking the test,

the students receive information about which mathematics courses they would be eligible to take at Ohio State or other colleges and universities that participate in the program. Students often conclude as a result of this test that they need to take mathematics during their senior year in high school. Typically when a high school starts using this testing service, enrollment in senior level mathematics courses increases by 40%.

Implications for Two-Year Colleges

As two-year colleges plan mathematics programs they should prepare for a student population that is even more diverse than the population they are serving now. The changes in elementary and secondary mathematics education that are being recommended today will occur unevenly from school to school and from teacher to teacher. The use of computers and calculators in the school curriculum will likely continue to be uneven; therefore, the best plan will be to prepare for everything. As schools place more emphasis on effective mathematics instruction, mathematics achievement of high school graduates may improve. That improvement will probably be accompanied by higher expectations by students for opportunities in careers and for education in two-year colleges and other post secondary institutions.

In this round of educational reform, the federal government is taking a more passive role than it did in the post-Sputnik era. As a result, the focus of change will be more at the state and local level. This local focus has implications for planning by two-year colleges, most of which tend to serve local populations, rather than regional or national populations. Direct contact with the high schools in the local area served will be even more important than an awareness of national trends.

In planning for the future, the two-year colleges can take a reactive role and just wait and see what kinds of students they will receive from the high

schools. In many two-year colleges, this approach has been taken in the past; the result has been that approximately 40% of the courses that students take in two-year colleges are courses that they should have successfully completed in high school.

An alternative approach would be to take a proactive role and work directly with the high schools to help students realize what mathematics courses they will need for the various programs offered in the two-year colleges. A National Assessment of Educational Progress survey found that the most influential factor related to students continuing to take mathematics in high school is how useful they think it will be.

High school mathematics teachers tend to appreciate communication with teachers in two-year colleges and other post secondary institutions that their graduates attend. The communication helps them improve their instruction and their ability to help counsel their students. The more closely the mathematics faculties of two-year colleges and high schools work together the more effective the mathematics programs at both levels will be.

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